DOCUMENT-IDENTIFIER: US 20030196993 A1

TITLE: Thermal flux deposition by scanning

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Summary of Invention Paragraph - BSTX (8):

[0008] Examples of heat treatments currently in use include Rapid Thermal Processing (RTP) and impulse (spike) **annealing**. While such processes are widely used, current technology is not ideal. It tends to ramp the temperature of the substrate too slowly and expose the substrate to elevated temperatures for too long. These problems become more severe with increasing substrate sizes, increasing switching speeds, and/or decreasing feature sizes.

Summary of Invention Paragraph - BSTX (14):

[0014] FIG. 1 also shows a thermal profile 104 of a laser **annealing** process. Laser **annealing** is used during the fabrication of Thin Film Transistor (TFT) panels. Such systems use a laser spot to melt and recrystalize polysilicon. The entire TFT panel is exposed by scanning the laser spot across successive exposure fields on the panel. For substrate applications a laser pulse is used to illuminate an exposure field for a duration of approximately 20-40 ns, where the exposure field is typically about 25 by 35 mm. As can be seen from the thermal profile 104 for laser **annealing,** the ramp rate is nearly instantaneous at billions of degrees per second. However, the laser pulse or flash used for laser **annealing** is too fast and, often does not provide enough time for sufficient **annealing** to occur for non-melt processes. Also, devices or structures next to the exposed regions may be exposed to extreme temperatures causing them to melt, or to temperatures that are too low resulting in too little **annealing**. Still further, homogenization of the thermal exposure of each portion of the substrate is difficult to attain because different regions adsorb at different rates resulting in huge temperature gradients. The process is too fast for thermal diffusion to equilibrate temperature, thereby creating severe pattern dependencies. As a result, this technology is not appropriate for single crystal silicon **annealing** because different regions on the substrate surface may be heated to vastly different temperatures causing large non-uniformities over short distances.

Summary of Invention Paragraph - BSTX (15):

[0015] Another thermal processing system currently in development by Vortek Industries Ltd., of Canada, uses flash assisted spike **annealing** to attempt to provide a high thermal energy to the substrate in a short of amount of time and then rapidly cool the region to limit the thermal exposure. Use of this thermal processing system should give the junction depth of a spike **anneal** to 1060.degree. C. but improve the activation with flash to 1100.degree. C. Typically, the RTP system ramps up to the desired temperature typically around 1060.degree. C. then begins to ramp down immediately after having reached the desired flash temperature. This is done to minimize the amount of diffusion that takes place while still getting suitable activation from the elevated temperature. The thermal profile 106 of such a flash assisted spike **anneal** is also shown in FIG. 1.

Summary of Invention Paragraph - BSTX (16):
[0016] In view of the above, there is a need for an apparatus and method for **annealing** a substrate with high ramp-up and ramp-down rates. This will offer greater control over the fabrication of smaller devices leading to increased performance. Furthermore, such an apparatus and method should ensure that every point of the substrate has a substantially homogenous thermal exposure, thereby reducing pattern dependencies and potential defects.

Summary of Invention Paragraph - BSTX (30):
[0029] According to yet another embodiment of the invention there is provided a thermal flux processing device. The thermal flux processing device includes a continuous wave electromagnetic radiation source, a stage, optics, and a translation mechanism. The **continuous wave electromagnetic** radiation source is preferably one or more **laser** diodes. The stage is configured to receive a substrate thereon. The optics are preferably disposed between the continuous wave electromagnetic radiation source and the stage and are configured to focus continuous wave electromagnetic radiation from the continuous wave electromagnetic radiation source into a line of continuous wave electromagnetic radiation on an upper surface of the substrate. A length of the line of continuous wave electromagnetic radiation preferably extends across an entire width of the substrate. The translation mechanism is configured to translate the stage and the line of continuous wave electromagnetic radiation relative to one another, and preferably includes a chuck for securely grasping the substrate.

Detail Description Paragraph - DETX (3):
[0045] FIG. 2A is a side view of an apparatus 200 for thermally processing a substrate, according to an embodiment of the invention. The thermal process is any thermal process that requires the characteristics of the invention described below. Exemplary embodiments of such a thermal process includes thermal **annealing** of substrates or thermal processes used in Chemical Vapor

Deposition (CVD), both of which will be described throughout the remainder of the Figures.

Detail Description Paragraph - DETX (6):
[0048] The continuous wave electromagnetic radiation source 202 is capable of emitting "continuous waves" or rays of electromagnetic radiation, such as light. By "continuous wave" it is meant that the radiation source is configured to emit radiation continuously, i.e., not a burst, pulse, or flash of radiation. This is quite unlike lasers used in laser **annealing,** which typically use a burst or flash of light.

Detail Description Paragraph - DETX (8):
[0050] In a preferred embodiment, the continuous wave electromagnetic radiation source 202 is capable of emitting radiation continuously for at least 15 seconds. Also, in a preferred embodiment, the **continuous wave electromagnetic** radiation source 202 comprises multiple **laser** diodes, each of which produces uniform and spatially coherent light at the same wavelength. In yet another preferred embodiment, the power of the laser diode/s is in the range of 0.5 kW to 50 kW, but preferably approximately 5 kW. Suitable laser diodes are made by Spectra-Physics of California, or by Cutting Edge Optronics, Inc. of St. Charles Mo. One such suitable laser diode is Spectra Physics' MONSOON.RTM. multi-bar module (MBM), which provides 40-480 watts of continuous
wave power per laser diode.

Detail Description Paragraph - DETX (25):
[0067] One concern of prior art laser **annealing** systems, regards stress related defects caused by rapidly heating relatively small areas of a substrate. Therefore, experimentation was undertaken to test whether the thermal flux processing of the present invention causes any stress related defects in the substrate. Peak stress occurs near the max temperature gradient, not the max temperature. If a line of radiation is suitably narrow and the depth of heating suitably shallow, it is possible to displace the region of maximum thermal gradient from the region of highest temperature, thereby increasing the slip window and decreasing defects. During this experimentation, a sample was scanned at 20 cm/s under a 400 microns wide line of radiation with a peak power density of 60 kW/cm.sup.2. The present invention was able to displace the peak thermal gradient from the peak temperature, thus enabling Ultra Shallow Junction (USJ) formation suitable for the 70 nm node with a 1 keV Boron implant without introducing any dislocations. Only the typical implant related defects were observed.

Detail Description Paragraph - DETX (35):
[0077] This process is repeated until a layer 614 (FIG. 6) having a predetermined thickness is formed on the upper surface 224 (FIG. 6) of the substrate 214 (FIG. 6). The predetermined scan speed is preferably faster than that required for thermal flux **annealing,** described above, as, multiple scans are required to build a film/layer. Typically, each deposited layer is between 8-10 angstroms. Required films/layers vary from 20 angstroms for tunnel oxide used in flash memory to 1500 angstroms for spacer applications. Therefore, the preferred scan speed is generally in the range of a few cm/sec to about 1 m/sec. The preferred line width 228 (FIG. 6) is the same as that described above.

Claims Text - CLTX (4):
3. The apparatus of claim 1, wherein said **continuous wave electromagnetic** radiation source is at least one **laser**.

Claims Text - CLTX (5):
4. The apparatus of claim 1, wherein said **continuous wave electromagnetic** radiation source is at least one **laser** diode.

Claims Text - CLTX (26):
25. The method of claim 23, comprising, prior to said focusing, emitting said **continuous wave electromagnetic** radiation from one or more **laser** diodes.

Claims Text - CLTX (38):
37. The thermal flux processing device of claim 35, wherein said **continuous wave electromagnetic** radiation source is at least one **laser**.

Claims Text - CLTX (39):
38. The thermal flux processing device of claim 35, wherein said **continuous wave electromagnetic** radiation source is at least one **laser** diode.

Claims Text - CLTX (58):
57. The method of claim 55, comprising, prior to said focusing, emitting said **continuous wave electromagnetic** radiation from one or more **laser** diodes.

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 20 | (amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment) with (laser) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:52 |
| L2 | 1 | 1 and (continuous with wave) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:46 |
| L3 | 5 | (amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment) with (laser) | USOCR; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2005/09/01 13:50 |
| L4 | 0 | ((amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment)) same (laser with (line or continuous)) | USOCR; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2005/09/01 13:51 |
| L5 | 0 | ((amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment)) same (laser with (line or continuous)) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:51 |
| L6 | 0 | ((amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment)) same (laser with (scan or scanning)) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:52 |
| L7 | 32 | ((amorphous adj carbon) with (anneal or annealing or treat or treated treating or treatment)) same (laser) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:52 |
| L8 | 12 | 7 not 1 | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:53 |
| L9 | 7356 | laser with (continuous adj wave) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:53 |
| L10 | 128 | laser with (continuous adj wave) with electromagnetic | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:58 |
| L11 | 92 | 10 and line | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:54 |
| L12 | 75 | 11 and @ad<"20031003" | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:00 |
| L13 | 0 | 12 and (amorphous adj carbon) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:55 |
| L14 | 13 | 12 and (carbon) | US-PGPUB; USPAT | OR | ON | 2005/09/01 13:55 |
| L15 | 18 | laser with (continuous adj wave) with electromagnetic | USOCR; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2005/09/01 14:00 |

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|---|---|---|---|---|---|---|
| L16 | 128 | laser with (continuous adj wave) with electromagnetic | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:00 |
| L17 | 45 | 16 and (anneal or annealing) | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:00 |
| L18 | 29 | 17 and @ad<"20031003" | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:12 |
| L19 | 0 | 18 and (amorphous adj carbon) | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:11 |
| L20 | 29 | 17 and @ad<"20031003" | US-PGPUB; USPAT | OR | ON | 2005/09/01 14:12 |